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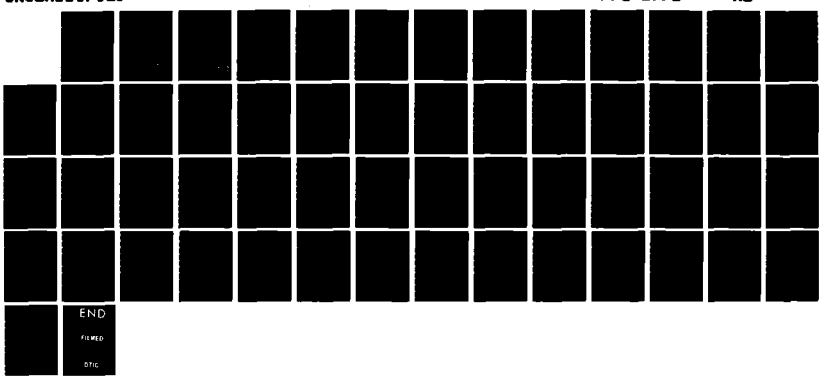

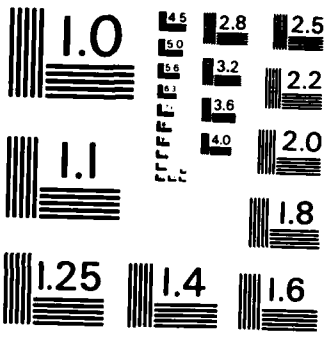

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NCS TIB 85-5

AD-A160 845

NATIONAL COMMUNICATIONS SYSTEM

TECHNICAL INFORMATION BULLETIN 85-5

TEST AND EVALUATION OF TELECONFERENCING VIDEO CODECS TRANSMITTING AT 1.5 Mbps

AUGUST 1985

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TEST AND EVALUATION OF TELECONFERENCING VIDEO CODECS TRANSMITTING AT 1.5 MBPS

AUGUST 1985

PROJECT OFFICER

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FOREWORD

Among the responsibilities assigned to the Office of the Manager, National Communications System, is the management of the Federal Telecommunication Standards Program. Under this program, the NCS, with the assistance of the Federal Telecommunication Standards Committee identifies, develops, and coordinates proposed Federal Standards which either contribute to the interoperability of functionally similar Federal telecommunication systems or to the achievement of a compatible and efficient interface between computer and telecommunication systems. In developing and coordinating these standards, a considerable amount of effort is expended in initiating and pursuing joint standards development efforts with appropriate technical committees of the Electronic Industries Association, the American National Standards Institute, the International Organization for Standardization, and the International Telegraph and Telephone Consultative Committee of the International Telecommunication Union. This Technical Information Bulletin presents an overview of an effort which is contributing to the development of compatible Federal, national, and international standards in the area of Coder/Decoders (Codecs) for Video Teleconferencing systems. It has been prepared to inform interested Federal activities of the progress of these efforts. Any comments, inputs or statements of requirements which could assist in the advancement of this work are welcome and should be addressed to:

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TEST AND EVALUATION
OF TELECONFERENCING VIDEO CODECS
TRANSMITTING AT 1.5 MBPS

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D E L T A I N F O R M A T I O N S Y S T E M S, I N C.

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SECTION 1 - EXECUTIVE SUMMARY

1.1 Background

This document summarizes work performed by Delta Information Systems, Inc. (DIS) for the Office of Technology and Standards of the National Communications System, an organization of the U.S. Government, under contract number DCA100-83-C-0047 Modification P00004. The work was performed under Subtask 3 (Performance of Codec Testing and Evaluation) under Task 3. Its known purpose was to vigorously evaluate the relative performace of all 1.544 mb/s video teleconferencing codecs on the market as of November 1984 to facilitate the choice of an appropriate frame format and data compression algorithm for a Federal Telecommunication Standard to meet the interoperability objectives of the NCS.

1.2 Scope

This report covers the testing and ranking of motion codecs for teleconferencing operating at 1.544 Mbps. The tests utilized the motion codec test tape previously developed under Subtask 1 of Task 3 (Development of Standard Video Materials) and followed the methodology previously developed under Subtask 2 of Task 3 (Development of Testing Methodology). Codecs developed by four manufacturers were tested; this included all units which were available as regular products before the end of November 1984. Since the results of these tests are likely to have considerable impact on the manufacturers, extreme care was taken to ensure absolute impartiality and

fairness in the procedure. Manufacturers' representatives actively participated in all testing and provided assurance that the results were representative of the performance capability of their equipment. The subjective evaluation and ranking of the codecs employed all possible safeguards against external influences by test equipments or test arrangements and against any personal prejudice of the evaluators. The test results and codec rankings are absolutely firm without the slightest doubt or ambiguity.

Section 2 of this report describes the codec tests that were performed at locations selected by each manufacturer. The test tape was processed in each codec and the outputs recorded on 1" tape for later evaluation. Section 3 covers the subjective evaluation and comparative scoring of the codec output tapes. It details the planning and implementation of the test setup, personnel selection, scheduling, test performance and initial review. Section 4 contains the computation of the numerical test results and the tanking of the codecs and several technical discussions of codec performance under standard and special conditions which back up the numerical results. Section 5 gives a brief conclusion and several recommendations for future test efforts.

SECTION2 - EQUIPMENT TESTS

2.1 General

Initially, all known or potential manufacturers of motion codecs operating at 1.544 Mbps and using the NTSC standard were solicited to establish equipment availability and interest in participating in the tests. It was stipulated that within the expected time frame of the tests (October/November 1984) the codec had to be available as a complete functional product line item. Developmental models or units still lacking an essential part (such as the line interface module) were not considered acceptable. This selection limited the number of codecs to be tested to four.

Great care was taken to achieve complete impartiality of the tests. The same copy of the 1" test tape was used in all instances. Connection between transmitter output and receiver input had to be made externally; internal loop-back if available was not allowed to be used. Selection of the test location was left to each manufacturer. Several engineers as assigned by the manufacturer participated in the tests, and they were given unlimited time to verify that the codec and the complete test setup were performing properly. In case even a slight discrepancy appeared, the test was repeated if requested by the manufacturer. Thus it can be guaranteed that the tapes recorded at the codec outputs accurately represent the best performance capabilities of each equipment.

The full length of the test tape was run through every codec.

This includes 46 sequences of motion and still scenes for regular performance evaluation, 3 identical sequences used with externally injected errors, and 18 test signals which are not part of the official evaluation, but are expected to be used later for further studies. Furthermore, the processed 46 regular sequences were run through the codec a second time to simulate a double hop; and upon request of the manufacturer recordings of other operational modes of the codec were made.

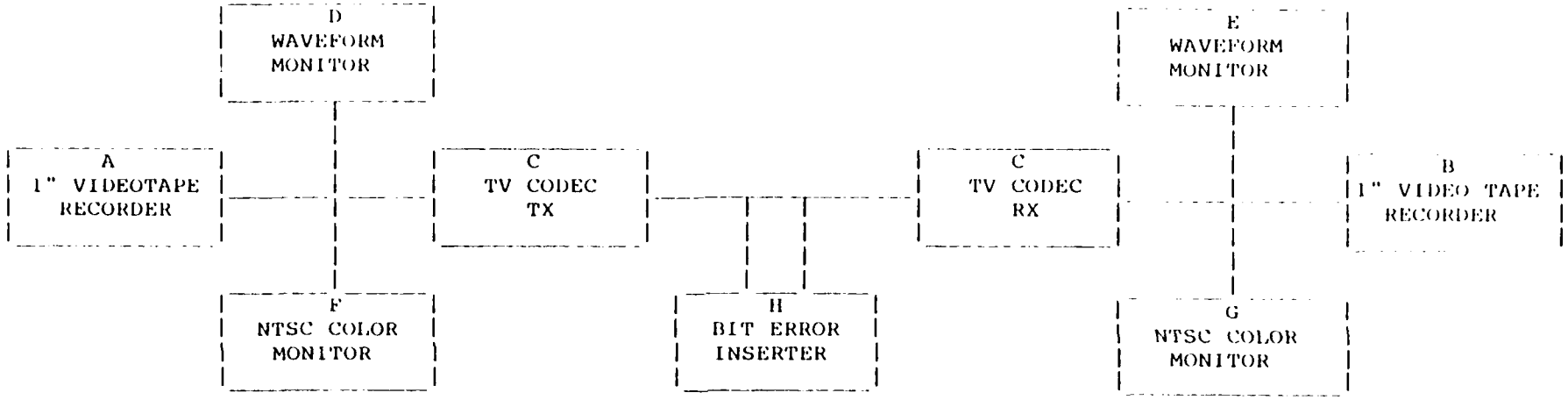
Brief descriptions of the individual tests are subsequently presented in chronological order.

2.2 GEC

The GEC tests were performed in Philadelphia where the test tape had been produced at the TV studio. The test setup block diagram is shown on Figure 2-1. The full complement of video tape and monitoring equipment was furnished by Center City Video. The bit error inserter was supplied by DIS. In addition to the test tape, double hop testing was performed.

2.3 Fujitsu

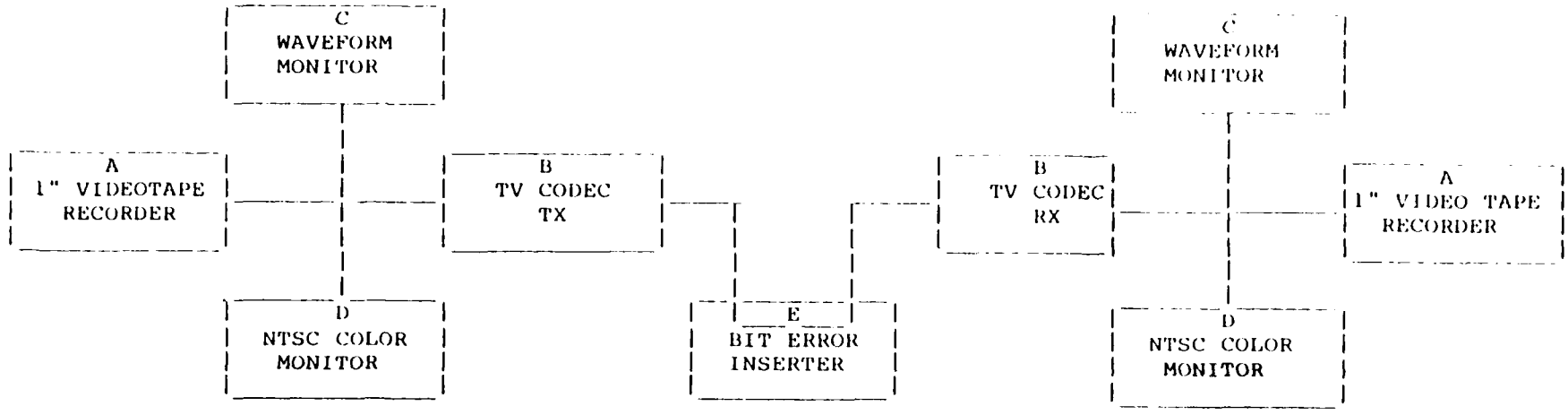
The tests on the Fujitsu FEDIS 1.5 equipment were performed at their facility in Kawasaki near Tokyo. The test setup is shown on Figure 2-2. All equipment was supplied by Fujitsu. A whole test bay was assigned to this fully integrated setup. Several engineers were present to continuously monitor equipment performance. Initially the performance with error insertion did not seem to come up to theoretical expectations, but after



LEGEND

A. 1" VIDEO TAPE RECORDER SONY BVH 1100A WITH TIME BASE CORRECTOR SONY BVT 2000
B. 1" VIDEO TAPE RECORDER SONY BVH 2000
C. GEC VIDEO TELECONFERENCE CODEC 525 LINE (1.50/0.77 MBIT/S)
D. TV WAVEFORM MONITOR TEKTRONIX 528A
E. TV WAVEFORM MONITOR TEKTRONIX 1480R WITH VECTOR SCOPE TEKTRONIX 520A
F. NTSC COLOR MONITOR VIDEOTEK PRO-12
G. NTSC COLOR MONITOR BARCO CTVM 2.51
H. BIT ERROR INSERTER GDP DLS-106 WITH INTERFACE CONVERTER GDP BAMI 726
(IN CIRCUIT ONLY FOR ERROR TESTS)

FIGURE 2-1 TEST SETUP - GEC



LEGEND

A. 1" VIDEO TAPE RECORDER SONY BVH-2500 (INCL. TIME BASE CORRECTOR
B. TV CODEC FUJITSU FEDIS 1.5(B)
C. TV WAVEFORM MONITOR TEKTRONIX 380
D. NTSC COLOR MONITOR SHIBASOKU CMM-14
E. RANDOM BIT ERROR INSERTER ANRITSU MS521A (WITH INTERNAL BYPASS)

FIGURE 2-2 TEST SETUP - FUJITSU

thorough checking the engineers found all equipment to be operating properly. Only the complete test tape was recorded through the codec.

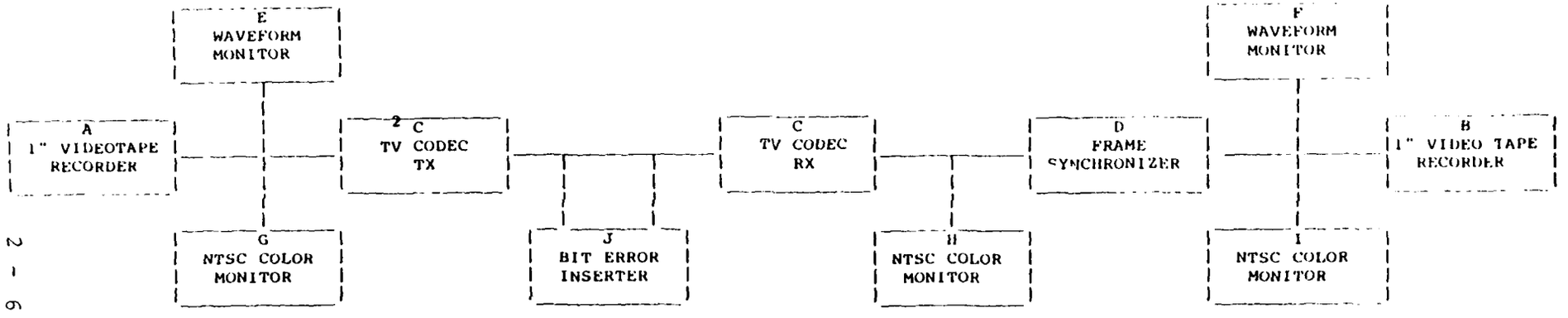
2.4 CLI

The tests on the CLI VTS-1.5 codec were performed at their facility in San Jose, California. The test setup is shown on Figure 2-3. The video tape recorders and part of the monitoring equipment were rented from a local TV production studio; The balance of the equipment was furnished by CLI, and the bit error inserter by DIS. A unit used only at CLI was the frame synchronizer which was needed to process the codec receiver signal before it could be recorded. This is due to the fact that the codec receiver output does not have the horizontal sync locked to the color subcarrier. This condition does not interfere with viewing the signal on a monitor but is incompatible with tape recording.

Engineers from both CLI and the supplier of the tape recorders participated in the alignment of the test setup. Level setting, particularly through the frame synchronizer, was quite critical and performed with extreme care. To set the proper reference level, a local color bar signal was recorded ahead of the test tape. In addition to the test tape, double hop performance was recorded.

2.5 NEC

The tests on the NEC NETEC-X1(MC) codec were performed at the

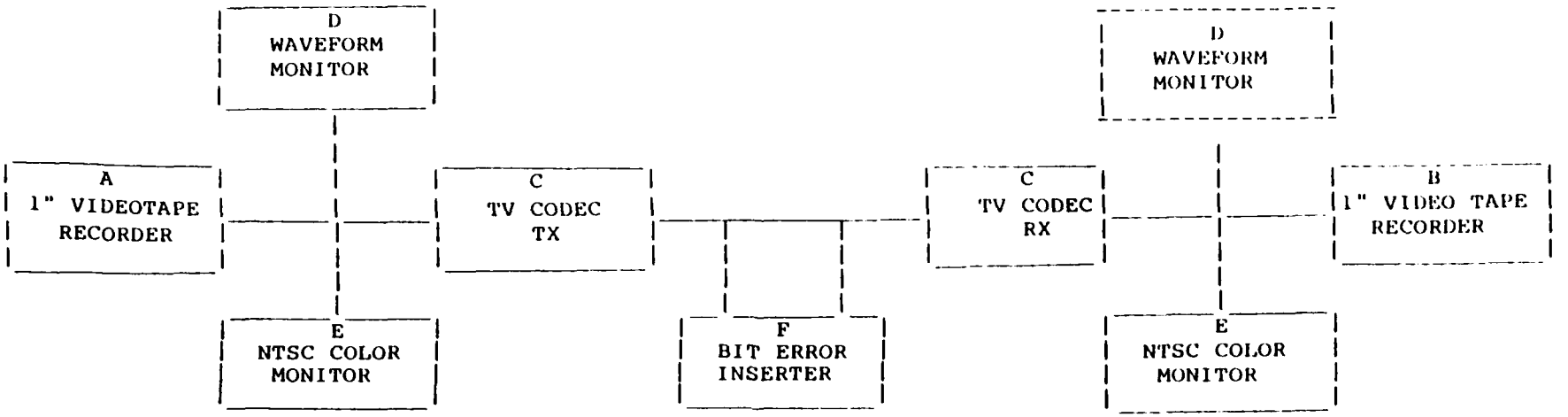


LEGEND

A. 1" VIDEO TAPE RECORDER AMPEX VPR-2 (INCL. TIME BASE CORRECTOR)
B. 1" VIDEO TAPE RECORDER SONY BVH-2000
C. TV CODEC CLI VTS-1.5
D. FRAME SYNCHRONIZER HARRIS 630
E. TV WAVEFORM MONITOR TEKTRONIX 528A
F. TV WAVEFORM MONITOR TEKTRONIX RM-529
G. NTSC COLOR MONITOR TEKTRONIX 650HR
H. NTSC COLOR MONITOR SHIBASOKU CM9A1
I. NTSC COLOR MONITOR SONY KX-901
J. BIT ERROR INSERTER GDP DLS-106 WITH INTERFACE CONVERTER BAMI 726
(IN CIRCUIT ONLY FOR ERROR TESTS)

FIGURE 2-1 TEST SETUP - CLI

NEC America facility at Fairfax, Virginia. The test setup is shown on Figure 2-4. The video tape recorders were provided by a local leasing company, the monitoring equipment by NEC and the bit error inserter by DIS. Several NEC engineers were present to handle the lineup and operation of the test setup. There were no problems with the codec proper. In addition to the test tape, a recording of double hop performance was made.



LEGEND

A. 1" VIDEO TAPE RECORDER NEC TT-7000 WITH TIME BASE CORRECTOR NEC NTC-10
B. 1" VIDEO TAPE RECORDER NEC TT-7000
C TV CODEC NEC NETEC - X1(MC)
D. TV WAVEFORM MONITOR TEKTRONIX 528A WITH VECTOR SCOPE TEKTRONIX 1420
(MOVED BETWEEN INPUT AND OUTPUT)
E. NTSC COLOR MONITOR NEC AUTO COLOR CM-1051A
F. BIT ERROR INSERTER GDP DLS-106 WITH INTERFACE CONVERTER GDP BAM1 726
(IN CIRCUIT ONLY FOR ERROR TESTS)

FIGURE 2-4 TEST SETUP - NEC

SECTION 3 - TEST TAPE SCORING

3.1 Planning

The subjective evaluation of the test tapes which have been processed through the various codecs represents one of the most critical phases of the overall program. The validity and integrity of the test results must be guaranteed beyond question. Not only must the test equipment operate flawlessly but the vagaries of the human element must be eliminated as much as possible. To satisfy these requirements the following factors must be considered:

- o Test setup and equipment check
- o Personnel numbers and selection
- o Test sequence scheduling

The chief quideline for planning the test tape scoring is CCIR Recommendation 500-2, Method for the Subjective Assessment of the Quality of Television Pictures, (Vol. XI, Part 1, XVth Plenery Assembly, Geneva, 1982).

3.1.1 Test Setup

The basic test requirements are satisfied by two 1" video tape recorders, two color monitors, and a double pole double throw switch to interchange the monitors. Equipment needed for checkout must be added. The monitors should have the largest screen size compatible with top quality performance. Only direct view monitors are recommended because projection monitors generally suffer from some loss in quality (both resolution and contrast)

and a limited viewing angle.

The viewing conditions should follow CCIR Rec. 500-2 as a guideline. Most of the parameters therein are stated in a rather loose form and do not require close adherence which would call for elaborate test equipment. Since the grading of the codec pictures is to be performed on a comparison basis, it is mainly important to ensure that both pictures will be viewed by all observers under essentially identical conditions. This makes the viewing distance a critical parameter. The recommended range is 4-6 times the picture height but a short viewing distance would seriously limit the number of possible observers. In practice, it seems desireable to allow a very small increase above the recommended range, particularly since existing teleconferencing installations have average viewing distances t the practical maximum number of simultaneous viewers is 5-6.

3.1.2 Personnel

Proper selection of the evaluating personnel is very important to achieve valid and impartial results. CCIR Rec. 500-2 and other pertinent publications distinguish between expert and non-expert observers, with the preference given to non-experts. This recommendation is being followed completely and is particularly applicable to the codec evaluation. An expert in video coding would most likely be able to identify a codec from the appearance of the picture which would make an impartial evaluation impossible. It is desirable to use observers who are as representative as possible of teleconference users. This

yields the most meaningful results. It was decided to recruit personnel, both male and female, from the middle management level of several branches of activities in selected organizations. It is unlikely that anybody with actual teleconferencing experience would be included but people should be chosen who are potential future users of expanded teleconferencing applications.

The recommended range of numbers of evaluators is 10 to 20. Considering the postulated careful personnel selection, it is felt that even the minimum number (10 to 12) will be adequate to achieve dependable results. However, even this minimum number is too high to make a tape comparison evaluation in one sitting; therefore the evaluators will have to be divided into two groups, and each test made twice.

3.1.3 Scheduling

The test tape has a running time of slightly above 30 minutes and contains 49 sequences. Three of these sequences are intentionally repeated for the purpose of displaying them on interchanged monitors to determine if possible differences in monitor quality may influence the results. The first repeated sequence is No. 25, just in the middle of the tape. Since 4 processed tapes are to be evaluated, a total of 6 different codec pairs are to be compared. All tests must be performed in two sections because of the two groups of evaluators, therefore 12 separate tests are required. With sufficient allowance for setup time and safety margin, one hour must be scheduled for each test. Therefore, the tests require a total period of two days.

The following designations are used on the schedule shown on Table 3-1:

Evaluator groups : X, Y

Codec test tapes : 1, 2, 3, 4

Tape recorders : A, B

Monitors : L, R (left, right)

This schedule was carefully prepared to eliminate any possible effects of equipment differences and test timing in order to guarantee a completely impartial evaluation. The following measures were taken for this purpose: (a) The monitors are interchanged between the first and second half of each tape. The assignment of each half of the tape to a monitor is reversed between the two sections of each test. (b) The assignment of each tape to a recorder is reversed between the two sections of each test. A tape is never assigned to the same recorder on consecutive tests. Thus each tape is always freshly threaded into a recorder. (c) The two sections of each test are scheduled on different days in reverse order. This eliminates possible effects of time of day and viewer fatigue. The two groups of viewers are scheduled alternately each every two hours, so that each person participates in only 3 tests per day. This is important to avoid fatigue.

DAY	1		1		1		1		1		1	
TEST NO.	1		2		3		4		5		6	
EVALUATOR GROUP	X		Y		X		Y		X		Y	
SEQUENCES	1-24	25-49	1-24	25-49	1-24	25-49	1-24	25-49	1-24	25-49	1-24	25-49
TAPE	1 2	1 2	2 4	2 4	3 4	3 4	2 3	2 3	1 3	1 3	1 4	1 4
TAPE PLAYER	A B	A B	A B	A B	B A	B A	B A	B A	A B	A B	B A	B A
MONITOR	L R	R L	L R	R L	R L	L R	L R	R L	L R	R L	L R	R L

DAY	2		2		2		2		2		2	
TEST NO.	7		8		9		10		11		12	
EVALUATOR GROUP	X		Y		X		Y		X		Y	
SEQUENCES	1-24	25-49	1-24	25-49	1-24	25-49	1-24	25-49	1-24	25-49	1-24	25-49
TAPE	4 1	4 1	3 1	3 1	3 2	3 2	4 3	4 3	4 2	4 2	2 1	2 1
TAPE PLAYER	B A	B A	A B	A B	B A	B A	B A	B A	A B	A B	A B	A B
MONITOR	L R	R L	L R	R L	L R	R L	R L	L R	L R	R L	L R	R L

TABLE 3-1 CODEC TEST TAPE EVALUATION SCHEDULE

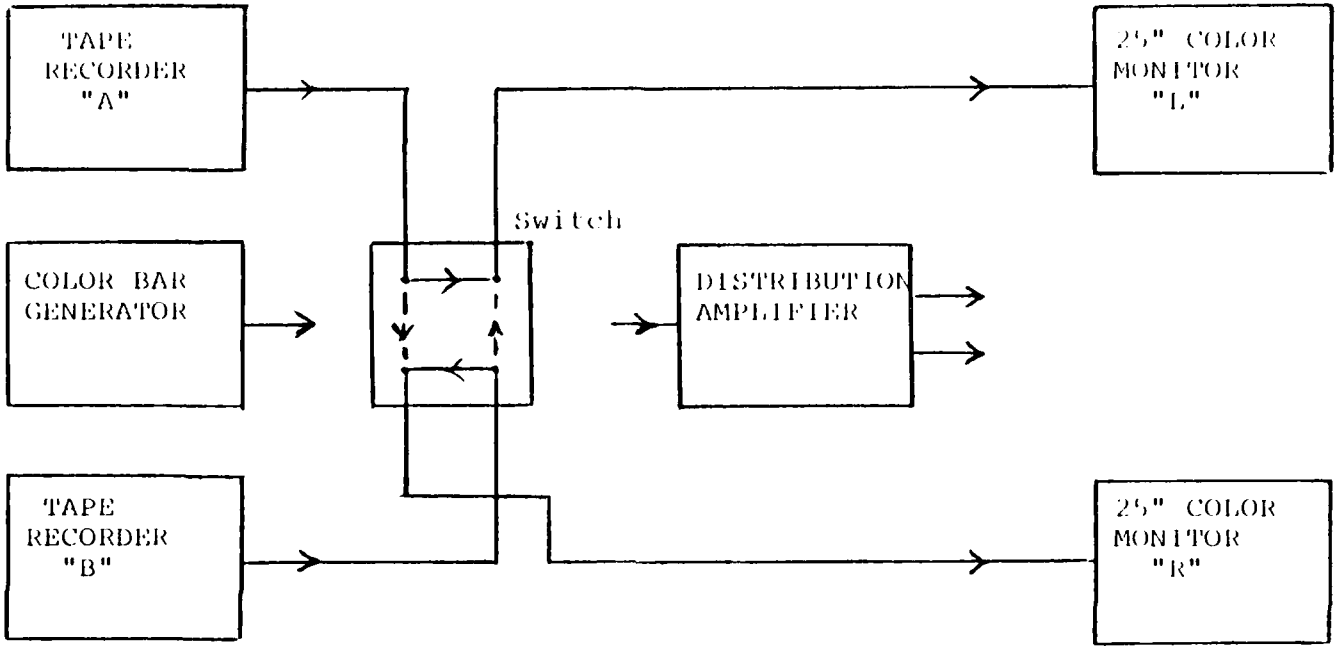
3.2 Implementation

3.2.1 Test setup

The schematic of the test setup on Figure 3-1 shows the arrangement of the previously mentioned basic equipment. In addition, a color bar generator and a distribution amplifier are available for equipment tests. the color bar generator provides a standard test signal, and the distribution amplifier allows displaying the same signal on both monitors to ensure perfectly matched adjustments. Properly matched video levels were verified by means of built-in indicators on the tape equipment.

Figure 3-1 gives the description of all equipment units. With the exception of the relay switch used for interchanging the monitors (which was built by DIS) all equipments were leased locally. The tape recorders are the standard of the industry for portable operation. The monitors were a model specially modified for computer use which features exceptionally good resolution without frequency response distortion.

The comparison tests were performed in a conference room in Delta Information System's facility in Horsham, Pa. Figure 3-2 shows the physical layout. The equipment was located on tables at both ends of the room. The monitor picture height was 15", therefore the ideal viewing distance was 7 1/2'. The front of each chair was located 7' from the center between the monitors which put the eyes of the viewers at an average distance of about 8'. The variation in viewing angles did not seem to make make any



EQUIPMENT DESCRIPTIONS:

TAPE RECORDER: SONY BVH-500A WITH CHROMA STABILIZER SONY HT-500A

25" COLOR MONITOR: ARCTURUS ARC 255 (MODIFIED SANYO AVM 255)

COLOR BAR GENERATOR: 3M 210-CB-SG

SWITCH: DELTA INFORMATION SYSTEMS, CUSTOM BUILT

DISTRIBUTION AMPLIFIER: COMPREHENSIVE VIDEO SUPPLY CORP. CVA 2B-4

FIGURE 3-1 TAPE COMPARISON TEST SETUP

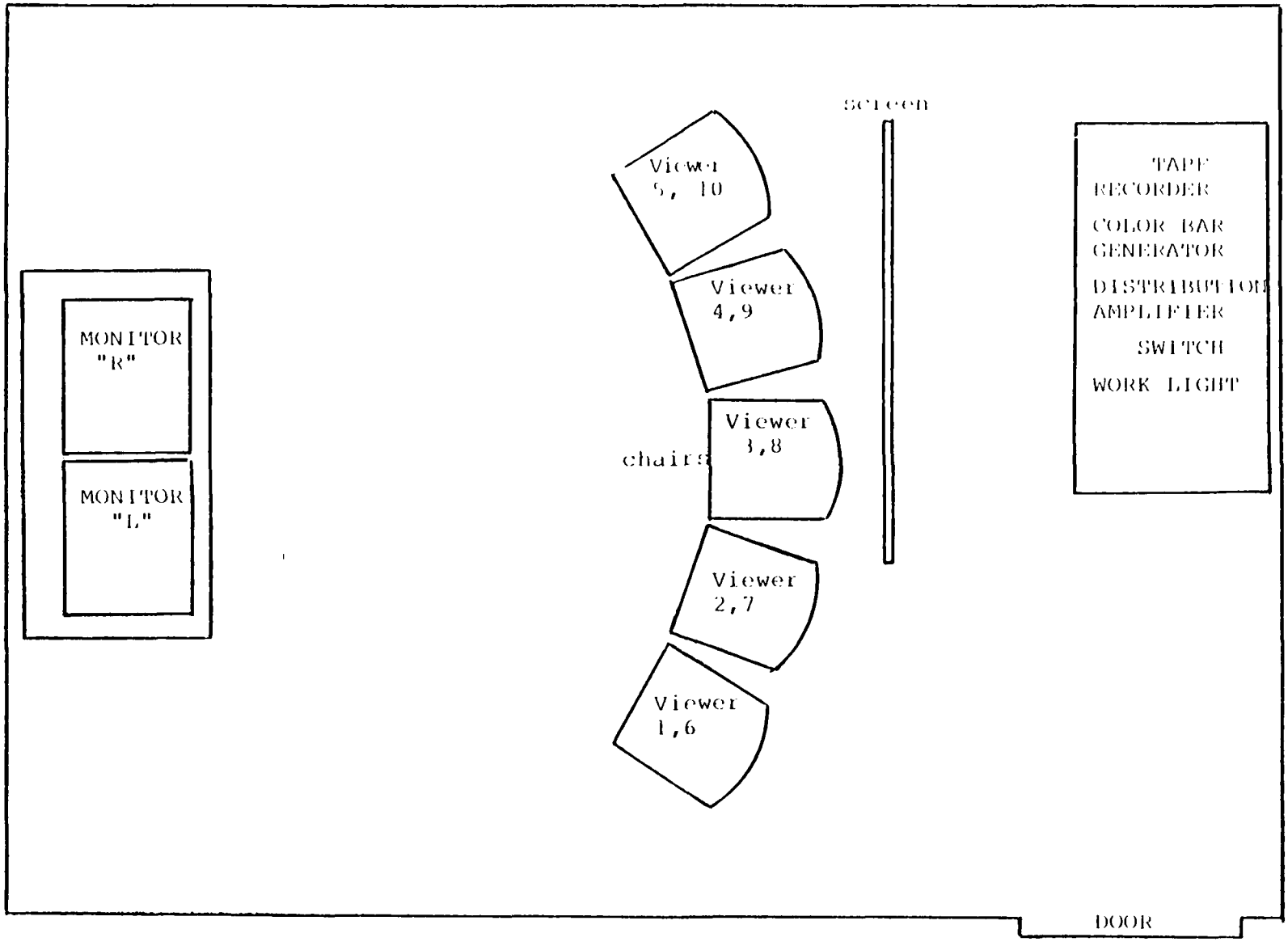


FIGURE 3-2 COMPARISON TEST ROOM LAYOUT

noticeable difference at this distance. The overhead lighting was reduced to provide about 25 foot candles on the wall behind the monitors and about 15 foot candles at the chairs of the observers which gave just enough light for marking the score sheets. A low level work light on the equipment table was mainly used for threading the tape recorders. A screen prevented any light reflections on the monitor fronts and also served to separate the operating personnel from the viewers.

3.2.2 Personnel

Since Delta Information Systems is located in a modern business center, several nearby companies provided sources for suitable observers with minimal logistics problems. The ten people selected were all of above average intelligence and represented a variety of backgrounds. Some were engineers; but none were experienced in the video field. Since it is considered important to maintain anonymity in the evaluation process, all viewers were given numbers by which they are identified for all purposes. Following is their approximate job description and affiliation.

Group X:

1. Engineering Manager, computer company, male
2. Communication Engineering Consultant, self-employed, male
3. Secretary, computer company, female
4. System Engineer, computer company, male
5. Chapter Officer, national civic organization, female

Group Y:

6. Marketing Representative, communication systems company, male

7. System Design Engineer, military systems company, male

8. Chief Accountant, communication engineering company, female

9. System Design Engineer, military systems company, male

10. System Analyst, military systems company, female

3.2.3 Test Performance

The rented equipment was delivered two days before the scheduled test date to allow familiarization and thorough checks of the complete setup. A rental company technician provided detailed instructions in the operation of the tape recorders and associated equipment. The monitors had been carefully aligned before delivery and required only very minor adjustments. Approximate compliance with CCIR Rec. 500-2 was checked with a light meter and by visual observation. For the comparison tests to be performed this factor is less important than the very close match of both monitors. This was accomplished visually by feeding identical signals, from both the color bar generator and the unprocessed test tape, to both monitors by means of the distribution amplifier. These tests were repeated every morning. The monitors proved to be extremely stable and required very little adjustment.

Table 3-2 shows the test schedule which was followed on the two days of the tests. Initially all ten evaluators were assembled for an introduction. The instructions included in Appendix A together with a sample score sheet, had all previously been given out to the observers. These were reviewed in detail during the introductions.

DAY	EVALUATOR GROUP	TIME						
		AM				PM		
		9	10	11	12	1	2	3 4
WED JAN 30	X	INTRO-DUCTION	TEST#1	LUNCH	TEST#3		TEST#5	
	Y	INTRO-DUCTION		TEST#2	LUNCH	TEST#4		TEST#6
THU JAN 21	X	TEST#7		TEST#9	LUNCH	TEST#11		
	Y		TEST#8	LUNCH	TEST#10		TEST #12	

TABLE 3-2 TEST PERFORMANCE SCHEDULE

The original unprocessed video tape was shown on both monitors to give the evaluators an idea what kind of pictures they will have to judge. Special suggestions were given regarding the sequences with error insertion. Questions for clarifications were solicited but none were forthcoming.

The test schedule was followed accurately throughout both days. No problems were encountered. Care had to be taken in cueing up and starting the tapes so they were synchronized to a time difference of well under 1/4 second. Any larger shift between the two pictures proved very annoying and would undoubtedly affect the accuracy of scoring. Once started, the two tape recorders maintained synchronism for the length of the tape.

3.3 Raw Data Review

Table 3-3 shows one sample of the 60 two-page score sheets which were filled in by the evaluators. It should be noticed that these sheets are completely anonymous. The evaluator is identified only by a number, and so is the test which is being scored. The codec numbers could be derived from the test numbers only by use of Table 3-1 which was not available to the evaluators. The assignment of numbers to each codec was at that time known only to a single person. No written record was made. Thus the evaluators could not obtain any information on the equipment under test and their impartiality can be firmly guaranteed.

The score sheet grades were translated into numerical scores by equating M=3, B=2, S=1. The sign of the score was determined

CODEC EVALUATION FORM

EVALUATOR: 5 TEST NO: 5

DATE: 1-30-85

GRADING SYSTEM

A; MUCH BETTER THAN	B; BETTER THAN	S; SLIGHTLY BETTER THAN	0; SAME AS

ENTER EVALUATION

TEST SEQ.	LEFT PICTURE BETTER			SAME AS	RIGHT PICTURE BETTER		
	A	B	S	0	S	B	A
1					X		
2			X				
3			9				
4				X			
5				X			
6					X		
7				X			
8				X			
9				X			
10				X			
11				X			
12					X		
13				X			

TEST SEQ.	LEFT PICTURE BETTER			SAME AS	RIGHT PICTURE BETTER		
	A	B	S	0	S	B	A
14				X			
15					X		
16				X			
17			X				
18				X			
19				X			
20		X					
21				X			
22				X			
23				X			
24			X				
25			X				
26				X			

CODEC EVALUATION FORM

(CONTINUATION)

EVALUATOR: 5 TEST NO: 5

DATE: 1-30-85

GRADING SYSTEM

A; MUCH BETTER THAN	B; BETTER THAN	S; SLIGHTLY BETTER THAN	0; SAME AS

ENTER EVALUATION

TEST SEQ.	LEFT PICTURE BETTER			SAME AS	RIGHT PICTURE BETTER		
	A	B	S	0	S	B	A
27		X					
28	X						
29	X						
30				X			
31	X						
32	X						
33				X			
34				X			
35				X			
36				X			
37	X						
38				X			

TEST SEQ.	LEFT PICTURE BETTER			SAME AS	RIGHT PICTURE BETTER		
	A	B	S	0	S	B	A
39				X			
40				X			
41				X			
42					X		
43		X					
44			X				
45				X			
46			X				
47			X				
48						X	
49					X		

TABLE 3-3 TYPICAL FILLED-IN SCORE SHEET

by stipulating a positive number in favor of the lower numbered codec, and a negative number in favor of the higher numbered codec. In order to facilitate transcribing the scores which are referenced only to monitor locations, the numbers of the 2 codecs under test together with the applicable sign of the score were added to each score sheet after completion by the evaluator. The reversal after sequence 24 is obvious.

A quick review of the score sheets shows fairly wide variations between evaluators which was to be expected due to the subjectivity of the tests. Some evaluators used mainly "equal" and "slightly better" while others made frequent use of "much better" and "better". However, in spite of these variations the general tendency of the scores is very consistent. The variations show no apparent correlation between seating, monitor locations and scores. The results of the monitor cross checks by means of repetition of sequences 11, 15 & 16 are shown on Table 3-4 which lists the scores of each original and repeated sequence given by all evaluators. Agreement is far from perfect but most differences (71 out of 180 cross checks or 39.4%) are only by one point which is an expected margin of error for a subjective test. There are only 10 differences (5.6%) of 2 points, one (.6%) points, and 3 (1.7%) reversals from +1 to -1. Larger numbers and size of differences seem to go with some codec pairs and evaluators. There is no consistency in the direction of the differences which might indicate a preference for one of the monitors. This was the main purpose of the repetition of sequences which has thereby proven its value.

TABLE 3-4 MONITOR CROSS-CHECK SCORES

TEST TAPE	SEQU-ENCES	EVALUATOR SCORES 1	2	3	4	5	6	7	8	9	10
	11/25	+1/+2	+2/+3	+1/+3	+1/+1	+2/+2	+2/+1	+1/+2	+1/+1	+2/+3	+1/+2
1-2	15/35	+2/+2	+1/+2	+2/+3	+3/+2	0/+1	+3/+2	+2/+2	+2/+2	+3/+3	+1/+3
	16/26	0/+2	+1/+3	+2/+3	+2/+1	+3/+3	+2/+1	+1/+1	+1/+1	+3/+3	+2/+2
	11/25	-1/+1	-1/0	0/-1	0/0	0/-1	0/-1	0/-1	-1/0	0/0	0/0
1-3	15/35	-1/-1	-1/-1	0/0	0/0	-1/+1	0/-1	-1/-1	0/-1	-1/0	-1/0
	16/26	-1/-1	-1/0	0/0	0/0	0/0	0/-1	-1/-1	-1/0	-1/0	-1/0
	11/25	+3/0	+2/+2	+1/+1	0/0	-1/0	-1/-1	0/+1	0/0	-1/0	+1/+1
1-4	15/35	0/-2	0/-1	0/0	-1/-1	0/0	-2/0	-1/-1	0/-1	-1/-1	-1/-1
	16/26	-2/-3	0/0	+1/+1	-1/-1	0/+1	-1/0	-1/-1	0/-1	-1/-1	0/-1
	11/25	-1/-3	-3/-3	-3/-3	-2/-2	-1/-1	-1/-1	-2/-1	-2/-2	-2/-2	-2/-2
2-3	15/35	-3/-2	-3/-3	-3/-3	-3/-3	-3/-3	-2/-2	-2/-2	-2/-3	-2/-2	-2/-2
	16/26	-3/-3	-3/-3	-3/-3	-2/-2	-3/-2	-2/-1	-1/-1	-3/-2	-3/-2	-2/-1
	11/25	-1/-2	-2/-2	-1/-1	-1/-1	-2/0	-2/-1	-2/-2	-2/-1	-2/-3	-2/-1
2-4	15/35	-3/-2	-3/-3	-3/-3	-3/-3	-2/-3	-2/-2	-2/-3	-3/-3	-2/-3	-3/-2
	16/26	-3/-3	-3/-3	-3/-3	-3/-2	-3/-2	-3/-2	-3/-2	-3/-3	-3/-2	-2/0
	11/25	+1/+1	+2/+2	+2/+2	0/+1	+1/+2	-1/0	+1/+1	+1/-1	+1/+1	+1/+1
3-4	15/35	+1/0	+1/0	+1/0	0/0	+2/0	-1/+1	+1/+1	+1/+1	+1/+1	0/0
	16/26	+2/+1	0/0	+1/+1	-1/-1	0/0	-1/0	+1/+1	+1/+1	0/0	+1/0

SECTION 4 - TEST RESULTS

4.1 Numerical Scores and Ranking

The 60 score sheets, a typical sample of which was shown on Table 3-3, were collated into 6 groups, one for each codec pair under test. Subsequently, the marked scores were translated into numbers from +3 to -3 and entered in matrix form into a computer as shown on Tables 4-1 to 4-6. Mean values and standard deviations were computed for each line (test sequence) and column (evaluator). The mean of either line or column mean values is the grade or comparitive score between the two codecs and is circled on each table.

The standard deviation values are not used directly for scoring but only to check the validity of the scores. If one particular test sequence showed a high standard deviation for several codec pairs, it would be an indication that this sequence presents serious problems and should possibly be eliminated from the computation of the comparative scores. Similarly, any evaluator with a mean score much different from the others in several instances must be considered suspect and should possibly be eliminated. However, close scrutiny of the results confirms that all scores are fully valid. Most standard deviations of test sequence scores are well below 1.00, and the few higher values are randomly scattered. The variations of the mean scores of the evaluators are caused by differences of opinion regarding the annoyance of different degradations and are within expected limits. The standard deviations of the evaluator scores mainly

CODEC 1: GEC
CODEC 2: FUJITSU

SEG	MEAN	STDEV	EVALUATORS 1	2	3	4	5	6	7	8	9	10
1	1.6	0.52	2	2	2	2	2	2	1	1	1	1
2	1.9	0.88	2	2	3	3	3	2	1	1	1	1
3	1.9	0.99	3	3	3	2	3	1	1	1	1	1
4	2.4	0.52	2	3	3	2	3	3	2	2	2	2
5	2.1	0.74	2	3	3	2	3	2	2	1	2	1
6	1.7	0.95	3	3	2	2	2	2	0	1	1	1
7	2.2	0.79	1	3	2	3	3	2	1	2	3	2
8	0.7	0.48	0	0	0	1	1	1	1	1	1	1
9	1.8	0.63	2	2	2	1	3	2	1	2	2	1
10	1.6	0.70	1	2	2	2	2	2	0	1	2	2
11	1.4	0.52	1	2	1	1	2	2	1	1	2	1
12	1.3	1.16	0	3	1	0	1	2	0	2	3	1
13	1.6	0.70	2	2	1	1	3	2	1	1	1	2
14	1.6	0.70	2	3	1	2	2	2	1	1	1	1
15	2.4	0.70	2	3	2	3	3	3	2	2	3	1
16	1.4	0.97	0	1	2	2	0	2	1	1	3	2
17	2.0	0.82	2	3	2	1	3	2	1	2	3	1
18	2.2	0.63	3	3	3	2	2	2	2	2	2	1
19	1.9	0.57	2	2	1	2	2	2	1	3	2	2
20	1.5	0.97	2	2	2	0	3	2	1	1	2	0
21	2.1	0.57	2	3	2	2	2	2	2	2	3	1
22	2.3	0.67	2	3	3	2	3	2	1	2	3	2
23	1.0	0.67	1	2	1	0	1	0	1	1	2	1
24	1.5	0.97	2	2	2	1	3	2	0	1	2	0
25	2.0	0.82	2	3	3	1	2	1	2	1	3	2
26	1.7	0.82	2	2	3	1	1	1	1	1	3	2
27	1.7	0.82	2	3	2	1	3	1	1	1	2	1
28	1.5	0.71	2	3	2	1	1	1	1	1	2	1
29	1.6	0.70	3	2	2	1	1	1	1	2	2	1
30	2.2	0.92	3	3	3	1	3	1	1	2	3	2
31	1.8	0.79	2	3	3	2	1	2	1	1	2	1
32	2.0	0.82	3	3	3	1	2	1	1	2	2	2
33	2.4	0.52	3	2	3	2	2	2	2	2	3	3
34	2.3	0.82	3	3	3	2	3	2	1	1	3	2
35	2.4	0.70	2	3	3	2	3	2	1	2	3	3
36	1.4	0.84	1	3	2	0	1	1	1	2	2	1
37	1.6	0.97	2	3	2	1	1	2	0	1	3	1
38	1.9	0.57	2	3	2	1	2	2	1	2	2	2
39	1.9	0.88	3	2	1	1	1	2	1	2	3	3
40	2.1	0.88	3	3	3	1	1	2	2	1	3	2
41	1.5	0.85	2	0	3	1	1	2	1	1	2	2
42	2.3	0.48	2	3	3	2	2	2	2	2	3	2
43	2.0	0.82	3	3	2	2	3	2	1	1	2	1
44	1.6	0.84	2	3	1	0	2	2	1	1	2	2
45	1.5	0.53	2	2	1	1	2	1	1	1	2	2
46	1.5	0.53	2	2	1	1	1	1	1	2	2	2
47	2.7	0.48	3	3	2	3	3	3	2	3	3	2
48	2.4	0.70	3	3	2	3	1	3	2	2	3	2
49	2.3	0.67	3	3	2	3	3	2	2	2	3	1
MEAN			2.04	2.51	2.10	1.51	2.06	1.80	1.14	1.51	2.27	1.51
STD.DEV.			0.83	0.68	0.80	0.78	0.89	0.59	0.57	0.55	0.73	0.71
GRADE			(1.84)									

TABLE 4-1 SCORE GEC VS. FUJITSU

CODEC 1: GEC
CODEC 3: CLI

SEQ	MEAN	STDEV	EVALUATORS 1	2	3	4	5	6	7	8	9	10
1	-1.8	0.63	-2	-2	-1	-1	-2	-2	-2	-2	-3	-1
2	0.0	0.94	-1	-1	0	1	0	2	0	0	-1	0
3	0.5	0.53	1	1	0	1	1	0	0	0	0	1
4	-0.2	0.92	-1	-2	0	0	0	1	1	-1	0	0
5	-0.9	0.74	-1	-2	-1	-1	0	0	-1	-1	-2	0
6	-1.6	0.70	-1	-3	-1	-1	-2	-2	-1	-2	-2	-1
7	-0.5	0.85	0	-1	1	0	0	0	-1	-1	-2	-1
8	-0.3	0.48	-1	0	0	0	0	-1	-1	0	0	0
9	-0.1	0.32	0	-1	0	0	0	0	0	0	0	0
10	-0.4	0.70	-1	-2	0	0	0	0	-1	0	0	0
11	-0.3	0.48	-1	-1	0	0	0	0	0	-1	0	0
12	-1.9	0.57	-2	-2	-1	-1	-2	-2	-2	-2	-3	-2
13	-0.6	0.70	-1	-2	-1	0	0	0	-1	-1	0	0
14	-0.1	0.57	-1	0	0	0	0	1	0	0	0	-1
15	-0.6	0.52	-1	-1	0	0	-1	0	-1	0	-1	-1
16	-0.6	0.52	-1	-1	0	0	0	0	-1	-1	-1	-1
17	-0.1	0.99	-1	-1	-1	1	1	1	1	-1	-1	0
18	0.3	0.48	1	0	0	1	0	0	1	0	0	0
19	-0.3	0.48	-1	-1	0	0	0	0	-1	0	0	0
20	-0.5	0.97	-1	-1	-1	-1	2	0	0	-1	-1	-1
21	-0.6	0.70	-1	-1	-1	-1	0	1	-1	-1	0	-1
22	-0.7	0.95	-2	-2	1	0	0	0	-1	-1	-1	-1
23	-0.7	0.48	-1	-1	0	-1	0	0	-1	-1	-1	-1
24	-0.8	0.92	-2	-2	-1	0	1	0	-1	-1	-1	-1
25	-0.3	0.67	1	0	-1	0	-1	-1	-1	0	0	0
26	-0.3	0.48	-1	0	0	0	0	-1	-1	0	0	0
27	-1.3	0.48	-1	-2	-1	-1	-2	-1	-1	-1	-1	-2
28	-1.5	0.71	-1	-2	-1	-1	-3	-2	-1	-1	-2	-1
29	-1.5	0.71	-2	-2	-1	-1	-3	-2	-1	-1	-1	-1
30	-0.3	0.82	0	-1	-1	-1	0	-1	0	1	-1	1
31	-2.3	0.67	-3	-3	-3	-1	-3	-2	-2	-2	-2	-2
32	-0.2	1.14	0	0	0	0	-3	0	-1	1	0	1
33	1.3	0.67	2	1	0	2	1	2	1	1	1	2
34	-0.4	0.70	-1	1	0	0	0	-1	-1	-1	0	-1
35	-0.4	0.70	-1	-1	0	0	1	-1	-1	-1	0	0
36	0.1	0.57	0	1	0	0	1	-1	0	0	0	0
37	-1.6	0.97	-1	-2	-3	0	-3	-2	-1	-1	-1	-2
38	1.0	0.94	1	2	-1	1	0	1	1	2	2	1
39	-0.1	0.32	-1	0	0	0	0	0	0	0	0	0
40	0.2	0.42	1	0	0	0	0	0	1	0	0	0
41	-0.8	0.79	-2	-2	-1	0	0	-1	-1	0	-1	0
42	-0.4	0.97	-1	-2	0	0	1	-1	-1	0	-1	1
43	-1.6	0.70	-2	-2	-2	-1	-2	-2	-1	-2	-2	0
44	-0.5	0.53	-1	-1	0	0	-1	-1	-1	0	0	0
45	-0.3	0.48	-1	0	0	0	0	-1	-1	0	0	0
46	-0.6	0.52	-1	0	-1	-1	-1	-1	-1	0	0	0
47	0.4	0.84	0	1	1	1	-1	1	-1	1	1	0
48	2.9	0.32	3	3	3	3	3	3	3	3	3	3
49	1.4	1.43	2	3	2	3	1	3	0	1	-1	3
MEAN			-0.65	-0.76	-0.35	0.00	-0.35	-0.27	-0.53	-0.37	-0.63	-0.40
STD.DEV.			1.01	1.16	0.82	0.72	1.30	1.07	0.85	0.88	1.00	0.90
GRADE			-0.43									

TABLE 4-2 SCORE GEC VS. CLI

CODEC 1: GEC
CODEC 4: NEC

EVALUATORS			1	2	3	4	5	6	7	8	9	10
GEC	MEAN	STDEV										
1	-0.9	0.57	0	0	-1	-1	-1	-1	-1	-1	-1	-2
2	0.1	1.20	2	1	1	0	0	-2	1	-1	-1	2
3	0.9	0.82	1	1	1	-1	0	0	-1	-1	0	2
4	0.7	1.34	3	2	2	1	0	-1	0	-1	0	1
5	1.1	0.57	1	2	2	0	1	1	1	1	1	1
6	-0.4	0.70	-1	0	1	0	-1	-1	-1	-1	0	0
7	1.1	0.57	2	1	1	1	1	1	0	1	2	1
8	0.0	0.94	1	1	1	0	0	-1	-1	-1	-1	1
9	0.4	0.84	1	1	1	1	0	-1	-1	1	0	1
10	-0.3	0.82	-1	1	0	0	0	-1	-1	-1	-1	1
11	0.4	1.35	3	2	1	0	-1	-1	0	0	-1	1
12	-1.0	0.4	-1	0	1	-1	-1	-2	-2	-1	-2	-1
13	0.1	0.57	1	0	0	0	0	-1	0	0	0	1
14	0.8	1.23	2	2	2	1	1	-2	1	0	0	1
15	-0.6	0.70	0	0	0	-1	0	-2	-1	0	-1	-1
16	-0.5	0.85	-2	0	1	-1	0	-1	-1	0	-1	0
17	0.9	0.88	1	2	2	1	0	-1	1	1	1	1
18	-0.2	0.63	-1	0	1	-1	0	0	-1	0	0	0
19	0.2	0.79	0	1	1	-1	0	-1	0	1	0	1
20	0.6	0.97	1	2	1	-1	0	-1	1	1	1	1
21	1.1	0.74	2	2	2	0	0	1	1	1	1	1
22	0.6	0.70	0	2	1	0	0	0	0	1	1	1
23	-0.1	0.99	1	0	1	0	0	-2	-1	1	-1	0
24	0.2	1.03	1	1	1	-1	1	-2	0	0	1	0
25	0.4	0.84	0	2	1	0	0	-1	1	0	0	1
26	-0.4	1.26	-3	0	1	1	1	0	-1	-1	-1	-1
27	-0.6	0.70	-1	-1	1	-1	-1	-1	-1	0	0	-1
28	0.1	0.88	0	1	1	-1	-1	1	0	0	1	-1
29	1.0	0.82	0	2	2	0	2	1	1	1	1	0
30	1.2	0.63	1	2	2	1	2	1	1	1	1	0
31	-0.6	0.84	-2	0	1	-1	0	-1	-1	-1	0	-1
32	0.7	0.67	0	2	1	0	0	1	1	1	1	0
33	-0.3	0.48	-1	0	0	-1	0	0	0	0	0	-1
34	-0.4	0.52	-1	0	0	-1	0	0	0	-1	0	-1
35	-0.8	0.63	-2	-1	0	-1	0	0	-1	-1	-1	-1
36	0.6	0.70	-1	1	1	1	1	1	1	0	1	0
37	-0.6	1.07	-1	1	1	0	-2	-1	0	-1	-1	-2
38	0.5	1.08	-2	2	1	0	1	1	0	1	1	0
39	0.1	0.57	-1	1	0	0	0	0	1	0	0	0
40	-0.9	0.57	-2	-1	0	-1	0	-1	-1	-1	-1	-1
41	-0.9	0.99	-2	-2	1	-1	0	-1	-1	-1	-2	0
42	1.6	0.52	1	2	2	2	1	2	2	1	2	1
43	0.4	1.07	-1	2	2	-1	0	1	0	0	1	0
44	0.4	0.70	-1	0	0	0	1	1	1	1	1	0
45	0.9	0.57	0	1	1	2	1	1	1	0	1	1
46	0.4	0.84	-1	1	1	1	1	1	0	0	1	-1
47	1.0	0.67	0	2	2	1	1	1	1	1	1	0
48	-0.8	1.17	-1	1	2	-1	-1	-1	-1	-1	-2	-1
49	2.0	0.67	2	3	2	3	2	2	2	1	2	1
	MEAN		-0.04	0.92	1.02	-0.04	0.18	-0.27	0.00	0.02	0.00	0.03
	STD.DEV.		1.46	0.97	0.69	0.76	0.80	1.01	0.68	0.83	0.91	0.92
	GRADE		(1.13)									

TABLE 4-3 SCORE GEC VS. NEC

CODEC 2: FUJITSU
CODEC 3: CLI

EVALUATORS		1	2	3	4	5	6	7	8	9	10
SEQ	MEAN STDEV										
1	-2.0 0.67	-2	-2	-3	-2	-3	-2	-1	-2	-2	-1
2	-1.6 0.84	-1	-2	-2	-2	-3	-2	-1	-2	-1	0
3	-1.1 0.88	-1	-1	-2	-1	1	-1	-2	-2	-1	-1
4	-2.0 0.82	-1	-2	-3	-2	-3	-3	-2	-2	-1	-1
5	-2.2 0.63	-1	-2	-2	-3	-3	-2	-3	-2	-2	-2
6	-2.6 0.52	-2	-3	-2	-3	-3	-2	-3	-3	-3	-2
7	-2.3 0.48	-2	-3	-2	-3	-2	-2	-2	-2	-3	-2
8	-1.0 0.67	-1	0	-2	-1	0	-2	-1	-1	-1	-1
9	-1.7 0.67	-1	-2	-2	-2	-3	-2	-2	-1	-1	-1
10	-1.6 0.52	-1	-2	-1	-2	-1	-2	-2	-1	-2	-2
11	-1.9 0.74	-1	-3	-3	-2	-1	-1	-2	-2	-2	-2
12	-2.4 0.84	-2	-3	-3	-3	-3	-1	-1	-3	-3	-2
13	-2.2 0.63	-2	-3	-3	-2	-2	-1	-2	-3	-2	-2
14	-1.6 0.52	-1	-2	-2	-2	-2	-2	-1	-2	-1	-1
15	-2.5 0.53	-3	-3	-3	-3	-3	-2	-2	-2	-2	-2
16	-2.5 0.71	-3	-3	-3	-2	-3	-2	-1	-3	-3	-2
17	-2.2 0.63	-2	-3	-3	-2	-3	-2	-2	-2	-1	-2
18	-2.2 0.63	-2	-3	-3	-3	-2	-1	-2	-2	-2	-2
19	-2.0 0.94	-2	-3	-3	-2	-3	-3	-1	-1	-1	-1
20	-2.0 0.82	-2	-3	-3	-2	-3	-2	-1	-2	-1	-1
21	-2.3 0.67	-3	-3	-3	-2	-3	-1	-2	-2	-2	-2
22	-2.2 0.79	-3	-3	-2	-3	-3	-2	-2	-1	-1	-2
23	-1.6 0.70	-3	-2	-2	-1	-1	-2	-1	-1	-1	-2
24	-0.8 1.75	-2	-3	-2	-2	-3	1	0	1	1	1
25	-2.0 0.82	-3	-3	-3	-2	-1	-1	-1	-2	-2	-2
26	-2.0 0.82	-3	-3	-3	-2	-2	-1	-1	-2	-2	-1
27	-2.5 0.53	-3	-3	-3	-3	-2	-2	-2	-2	-2	-3
28	-2.3 0.67	-3	-3	-2	-3	-2	-1	-2	-2	-3	-2
29	-2.7 0.48	-3	-3	-3	-3	-3	-2	-3	-3	-2	-2
30	-2.0 0.67	-2	-3	-3	-2	-2	-2	-2	-2	-1	-1
31	-2.7 0.48	-3	-3	-3	-3	-3	-2	-3	-2	-3	-2
32	-1.9 0.74	-3	-2	-3	-1	-2	-2	-2	-1	-1	-2
33	-1.7 1.06	-2	-3	-3	-2	-3	-1	-1	-1	-1	0
34	-2.4 0.70	-3	-3	-3	-3	-3	-2	-2	-2	-2	-1
35	-2.5 0.53	-2	-3	-3	-3	-3	-2	-2	-3	-2	-2
36	-1.5 0.71	-1	-2	-3	-1	-2	-2	-1	-1	-1	-1
37	-2.5 0.53	-3	-3	-3	-2	-3	-2	-3	-2	-2	-2
38	-0.7 1.25	0	-1	-3	-1	2	-1	0	-1	-1	-1
39	-1.2 0.92	-3	-2	0	-2	-1	-1	0	-1	-1	-1
40	-2.1 0.57	-2	-3	-3	-2	-2	-2	-2	-2	-2	-1
41	-2.3 0.48	-3	-3	-3	-2	-2	-2	-2	-2	-2	-2
42	-2.6 0.52	-3	-3	-3	-3	-2	-2	-2	-3	-3	-2
43	-2.8 0.42	-3	-3	-3	-3	-3	-2	-3	-3	-3	-2
44	-2.2 0.92	-3	-3	-3	-3	-3	-1	-2	-1	-2	-1
45	-1.9 0.74	-3	-2	-3	-2	-2	-1	-2	-1	-1	-2
46	-1.9 0.88	-3	-3	-3	-2	-2	-1	-1	-1	-1	-2
47	-2.4 0.84	-3	-3	-3	-3	-2	-2	-1	-3	-3	-1
48	0.8 0.92	0	2	0	0	2	2	1	0	1	0
49	-1.2 1.23	0	-2	-3	0	-3	-2	0	-1	-1	0
MEAN		-2.12	-2.49	-2.59	-2.14	-2.12	-1.59	-1.59	-1.78	-1.65	-1.48
STD.DEV.		0.86	0.71	0.68	0.68	1.17	0.69	0.80	0.79	0.83	0.75
GRADE		-1.96									

TABLE 4-4 SCOPE FUJITSU VS. CLI

CODEC EVALUATION

CODEC 2: FUJITSU
CODEC 4: NEC

SEQ	MEAN	STDEV	EVALUATORS 1	2	3	4	5	6	7	8	9	10
1	-1.4	0.97	-2	-1	1	-2	-2	-2	-2	-2	-1	-1
2	-1.9	0.88	-1	-2	-1	-2	-1	-3	-3	-2	-3	-1
3	-2.2	0.42	-2	-3	-2	-2	-2	-2	-2	-3	-2	-2
4	-1.5	0.71	0	-2	-1	-2	-2	-2	-1	-2	-2	-1
5	-1.0	0.82	0	-1	0	0	-2	-1	-1	-2	-2	-1
6	-2.1	0.88	-2	-2	0	-2	-2	-2	-3	-3	-3	-2
7	-1.3	1.06	0	0	0	-1	-2	-2	-1	-2	-3	-2
8	-0.6	1.26	-1	1	2	0	-1	-1	-2	-1	-2	-1
9	-1.4	0.84	-1	-1	-1	-1	-2	-2	0	-3	-1	-2
10	-2.1	0.99	0	-2	-1	-2	-3	-2	-3	-2	-3	-3
11	-1.7	0.48	-1	-2	-1	-1	-2	-2	-2	-2	-2	-2
12	-2.2	0.63	-2	-2	-1	-3	-2	-3	-2	-2	-3	-2
13	-1.4	0.52	-1	-2	-1	-1	-2	-1	-1	-2	-1	-2
14	-1.7	0.82	-2	-2	-1	-2	-2	-3	0	-2	-2	-1
15	-2.7	0.48	-3	-3	-3	-3	-2	-2	-2	-3	-3	-3
16	-2.9	0.32	-3	-3	-3	-3	-3	-3	-3	-3	-3	-2
17	-2.2	0.92	0	-3	-2	-2	-3	-2	-2	-2	-3	-3
18	-2.6	0.70	-3	-3	-3	-3	-3	-1	-2	-3	-3	-2
19	-1.4	0.70	-1	-2	0	-2	-2	-2	-1	-2	-1	-1
20	-1.0	1.41	0	2	-1	-2	-2	-3	0	-1	-2	-1
21	-1.1	0.88	-1	-2	-1	-2	-1	-1	1	-2	-1	-1
22	-1.1	0.88	-1	-2	1	-1	-1	-1	-2	-1	-1	-2
23	-1.2	0.92	-2	-1	1	-1	-2	-2	-1	-1	-1	-2
24	-1.4	0.70	-1	-1	-1	-2	-2	-3	-1	-1	-1	-1
25	-1.4	0.84	-2	-2	-1	-1	0	-1	-2	-1	-3	-1
26	-2.2	0.92	-3	-3	-3	-2	-2	-2	-2	-3	-2	0
27	-1.9	0.88	-2	-3	-1	-3	-1	-1	-3	-1	-2	-2
28	-1.2	0.63	-2	-1	-1	-1	-1	0	-2	-1	-1	-2
29	-1.1	1.10	-2	-2	1	-2	0	0	-2	-1	-1	-2
30	-1.4	0.84	-1	-3	-1	-2	-1	-1	0	-2	-2	-1
31	-2.1	0.74	-2	-2	-2	-3	-3	-1	-2	-1	-3	-2
32	-1.6	0.70	-2	-3	-2	-1	-1	-1	-2	-2	-1	-1
33	-2.3	0.82	-3	-3	-3	-2	-3	-2	-1	-3	-1	-2
34	-2.3	0.67	-3	-3	-3	-2	-3	-2	-1	-2	-2	-2
35	-2.7	0.48	-2	-3	-3	-3	-3	-2	-3	-3	-3	-2
36	-1.1	0.57	-1	-2	-2	-1	0	-1	-1	-1	-1	-1
37	-1.6	1.51	-2	-2	2	-2	-3	0	-2	-2	-3	-2
38	-1.6	0.70	-1	-2	-1	-2	-1	-1	-2	-2	-1	-3
39	-1.4	0.70	-2	-2	0	-2	-1	-2	-1	-1	-1	-2
40	-2.4	0.70	-2	-3	-3	-2	-3	-2	-2	-3	-3	-1
41	-2.3	0.67	-2	-3	-3	-1	-2	-2	-3	-2	-3	-2
42	-1.5	0.53	-1	-2	-1	-1	-1	-1	-2	-2	-2	-2
43	-1.9	0.57	-2	-2	-1	-2	-2	-2	-2	-2	-3	-1
44	-1.9	0.57	-2	-2	-1	-1	-2	-2	-2	-2	-3	-2
45	-1.3	0.82	-1	-2	0	-2	-2	0	-2	-1	-1	-2
46	-1.0	0.67	-1	-2	0	-1	-1	0	-2	-1	-1	-1
47	-2.6	0.52	-3	-3	-2	-3	-2	-2	-3	-3	-3	-2
48	-2.9	0.32	-3	-3	-2	-3	-3	-3	-3	-3	-3	-3
49	0.0	0.00	0	0	0	0	0	0	0	0	0	0
	MEAN		-1.57	-1.98	-1.06	-1.78	-1.82	-1.61	-1.69	-1.92	-1.98	-1.88
	STD.DEV.		0.93	1.11	1.40	0.78	0.89	0.83	0.96	0.75	0.86	0.69
	GRADE		-1.71									

TABLE 4-5 SCORE FUJITSU VS. NEC

CODEC EVALUATION

CODEC 3: CLI
CODEC 4: NEC

SEQ	MEAN	STDEV	EVALUATORS 1	2	3	4	5	6	7	8	9	10
1	1.8	0.63	3	2	1	1	2	2	2	1	2	2
2	0.7	1.34	3	1	1	0	0	-2	1	1	2	1
3	-0.6	0.70	-1	0	-1	-1	-1	-1	0	1	-1	-1
4	1.0	0.82	2	2	1	1	1	-1	1	1	1	1
5	1.8	0.63	2	3	1	1	1	2	2	2	2	2
6	1.4	0.97	2	3	2	1	1	0	0	1	2	2
7	2.0	0.94	2	3	3	1	2	2	0	2	3	2
8	0.5	0.97	1	0	1	0	1	-1	-1	1	1	2
9	1.5	0.53	1	2	2	1	1	2	1	2	2	1
10	0.6	0.97	1	0	2	0	2	-1	0	1	0	1
11	1.0	0.94	2	2	2	0	1	-1	1	1	1	1
12	1.3	1.06	2	1	3	0	3	1	1	1	0	1
13	0.7	0.82	2	1	0	0	2	0	1	0	0	1
14	0.9	0.74	1	1	2	0	0	1	0	1	1	2
15	0.5	0.97	1	1	1	0	2	-1	-1	1	1	0
16	0.2	1.03	2	0	1	-1	0	-1	-1	1	0	1
17	1.1	1.20	1	1	2	-1	-1	2	1	2	2	2
18	-0.2	0.63	1	-1	0	0	0	-1	-1	0	0	0
19	0.5	0.85	2	0	0	0	0	0	0	1	0	2
20	1.7	0.48	2	2	2	1	1	2	1	2	2	2
21	1.7	0.95	2	3	2	0	0	2	2	2	2	2
22	2.0	0.67	3	3	2	1	2	2	1	2	2	2
23	0.5	0.71	1	0	1	-1	1	0	0	1	1	1
24	1.5	0.53	2	2	2	1	1	1	1	2	1	2
25	1.0	0.94	1	2	2	1	2	0	1	-1	1	1
26	0.3	0.67	1	0	1	-1	0	0	1	1	0	0
27	1.1	0.57	1	1	1	0	2	2	1	1	1	1
28	1.7	0.48	1	2	2	1	2	2	1	2	2	2
29	1.8	0.42	1	2	2	1	2	2	2	2	2	2
30	1.4	0.84	0	2	2	0	2	2	1	2	2	1
31	1.5	0.71	1	2	3	1	2	1	2	1	1	1
32	1.1	0.57	1	1	2	0	2	1	1	1	1	1
33	-0.9	0.74	-1	0	0	-1	0	-1	-1	-1	-2	-2
34	0.2	0.63	-1	0	0	1	0	0	0	1	0	1
35	0.4	0.52	0	0	0	0	0	1	1	1	1	0
36	1.0	0.67	1	1	1	0	2	2	1	1	0	1
37	1.6	0.84	1	2	3	1	3	2	1	1	1	1
38	-0.8	1.32	-1	-1	2	-2	1	-1	-1	-1	-2	-2
39	0.4	0.52	0	1	0	0	0	1	1	0	0	1
40	-0.8	0.42	-1	0	0	-1	-1	-1	-1	-1	-1	-1
41	0.5	0.71	0	0	2	1	0	0	1	0	0	1
42	1.8	0.92	1	3	2	0	1	2	2	3	2	2
43	1.5	0.85	1	3	3	1	1	1	1	1	2	1
44	0.8	0.63	1	0	1	0	1	2	1	1	1	0
45	1.3	0.67	1	1	2	0	1	2	2	1	1	2
46	1.1	0.57	1	2	2	0	1	1	1	1	1	1
47	1.2	0.92	1	2	2	0	3	1	0	1	1	1
48	-2.4	1.26	-2	-3	1	-3	-3	-3	-3	-2	-3	-3
49	0.6	0.97	0	1	1	0	0	-1	2	1	2	0
MEAN			1.00	1.14	1.43	0.10	0.94	0.55	0.61	0.96	0.85	0.98
STD.DEV.			1.39	1.13	1.00	0.80	1.07	1.30	0.93	0.88	1.14	1.07
GRADE			(0.856)									

TABLE 4-6 SCORE CLI VS. NEC

reflect the tendency to use "much better" and "better" scores more or less frequently but a high value can also indicate very erratic scoring.

When looking at the mean scores of each evaluator on Tables 4-1 to 4-6, it is interesting to note that in 5 of the codec comparisons, the scores are unanimous. Only in the case of GEC vs. NEC is there a split decision but the majority and the numerical values clearly favor GEC.

Table 4-7 summarizes the individual results. The ranking matrix gives the mean of the scores of each codec against the 3 others and results in the following ranking.

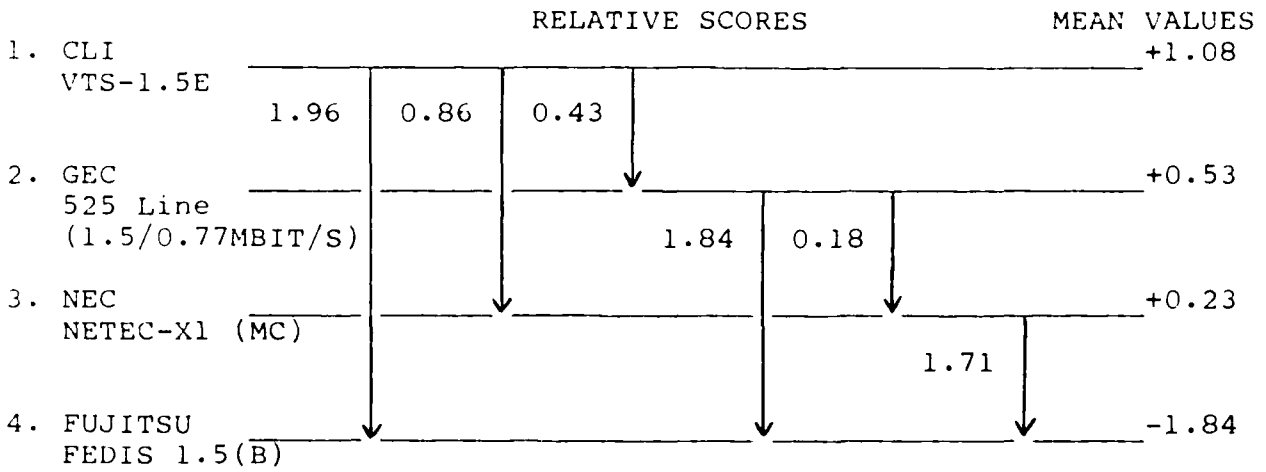
		Model No.
1.	CLI	VTS-1.5 E
2.	GEC	525 Line (1.5/0.77 MBIT/S)
3.	NEC	NETEC-X1 (MC)
4.	Fujitsu	FEDIS 1.5 (B)

The score comparison chart shows graphically both the relative scores and the resulting mean values. Obviously, this chart is not to scale and the various numbers cannot add up because they represent means derived in different steps from independent subjective scores. The value of the chart is that it shows full consistency of the results. All score differences are in the same direction, there is no reversal which would indicate a possible ambiguity. Thus the validity of the final ranking can be firmly guaranteed.

To get further data regarding the most critical No. 1 and 2 ranks, three experts performed the comparison scoring test.

CODEC NO.						MEAN	RANK	MANUFACTURER
CODEC NO.	1	2	3	4				
1	-	1.84	-0.43	0.18	1.59	+0.53	2	GEC
2	-1.84	-	-1.96	-1.71	-5.51	-1.84	4	FUJITSU
3	0.43	1.96	-	0.86	3.25	+1.081	1	CLI
4	-0.18	1.71	-0.86	-	0.67	+0.23	3	NEC

RANKING MATRIX



SCORE COMPARISON

TABLE 4-7 CODEC RANKING

The three scores were: -1.49, -0.67, -0.53, resulting in a mean of -0.90. This fully confirms the official score. As a matter of fact, the numerical value is twice the official score in favor of CLI which is caused by the fact that experts tend to use high level scores (such as "much better") more freely than non-experts.

4.2 Discussion of Degradations

The numerical test results are fully consistent and need no further justification. However, it is desirable to perform a brief technical analysis of the degradation caused by each codec to establish a rationale behind the subjective scores. The various evaluators obviously had different opinions regarding the impact of each degradation.

The most noticeable degradation that can be caused by the CLI codec is a series of spurious colored squares or stripes. They appear only very infrequently, and seem to be caused by certain picture configurations. They do not seem to be a random occurrence since they happened several times at the same spots on the tape. Some motion has a slightly jerky appearance. There is a slight color shift towards yellow which may be due either to the codec proper or to a slight misadjustment in the frame synchronizer which had to be inserted in order to make the codec output compatible with the tape recorder. In normal operation this unit is not needed, the regular codec output can be connected to any color monitor or to the input of another codec.

The GEC codec suffers most obviously during scenes with

moderate to agitated motion which causes severe tearout in the bottom half of the picture. Some of the same problem is also noticeable after switching. Edges become quite ragged during motion. Furthermore, any type of motion including switching leaves a coarsely grained after image for about 1 to 3 seconds. This image disappears in a downward wipe.

The most disturbing effect of the NEC codec is the formation of spurious contour patterns, largely in the background, with any motion, at times even in a still picture. Any slight change or movement in the picture causes a change in this pattern which makes it much more noticeable. A moving object becomes blurry. There is a small but noticeable loss of chroma amplitude through the codec.

The Fujitsu codec has one deficiency which overshadows all other problems. It evidently can process only a limited amount of change between successive frames. When this limit is reached the codec simply stops processing the picture change and displays the contents of the previous frame. This produces one or a series of wide horizontal stripes containing portions of one or several previous frames in the bottom of the picture. This effect is annoying, and also destroys picture information. In addition, edges become very ragged in motion, and some blurring and spurious contours are also noticeable. A switch between pictures appears like a vertical wipe.

4.3 Performance under Error Conditions

Sequences 47, 48, and 49 on the test tape are identical and

were used with inserted error rates of 10^{-5}, 10^{-4}, and 10^{-3} respectively, which of course causes the output image to degrade to varying degrees. Thus performance conditions is included in the general evaluation but with the low weighting of 3/49 or about 6%. This is fully justifiable since most transmission circuits are good and error conditions occur only very infrequently.

Scoring of the sequences with errors proved to be somewhat difficult for the non-expert evaluators because they do not have the knowledge to separate the effect of errors from other picture degradation and it was not feasible to give them specific instructions in this matter. At a low error rate (10^{-5}) the degratation due to errors may be so slight that the score was based on picture differences without errors which was not intended. On the other hand, at a high error rate (10^{-3}) the codec may cease functioning and go into a freeze-frame mode showing a still picture without disturbance which probably would be scored higher than an unrecognizable picture even though both are equivalent and indicate a complete codec malfunction.

However, a brief discussion of performance under error conditions based on "expert" observations is desirable in case it is ever necessary to use a codec over a considerably degraded transmission circuit.

The error test sequences consist of two scenes, one with slight and one with moderate motion. The influence of error is decidedly more pronounced with increased motion.

At an error rate of 10^{-5}, NEC shows no noticeable

degradation. This is due to the fact that a more powerful forward error correction code is used than in the other units. GEC shows some small colored dots and very few short colored streaks. CLI has occasional colored bands accross the picture. Fujitsu suffers from an occasional complete loss of picture.

Performance at an error rate of 10^{-4} is somewhat similar but more deteriorated. NEC shows occasional colored blotches and a few streaks but the overall picture is only very slightly disturbed. The colored dots and streaks in the GEC codec are more frequent and the streaks much longer but the degradation is not serious. CLI shows severe disturbance by wide colored bands which at times almost obliterate the picture. Fujitsu has complete picture loss for a large portion of the time.

An error rate of 10^{-3} is very high and digital equipments cannot be expected to operate properly. However, the GEC codec, though severely disturbed by long colored streaks, maintains a recognizable picture with sync and color intact can be considered marginally usable. All other units produce either freeze frame or complete picture loss and thus are called totally unusable.

4.4 Double Hop Performance

Though not required, it was deemed valuable to unofficially evaluate "double hop" (tandem) perfcrmance of codecs, using the output tape processed through each codec as input and making a second recording. Time limitations made it impossible to do this at Fujitsu. It is anticipated that there will be occasions of either long haul transmissions over two satellite links or usage

in various networks where a picture will have to be processed through two codecs in tandem, and it was assumed that both will be of the same type.

A very limited subjective evaluation was performed by three non-expert DIS employees. The two comparison scores that were obtained and are shown on Table 4-8 fully confirm the ranking developed in 4.1 As a matter of fact, the difference scores of CLI vs GEC (.75) and GEC vs NEC (1.07) are so much more pronounced than those in 4.1 that a comparison test between CLI and NEC would not have added any useful information.

It has thus been established that adding a requirement of double hop performance would have no effect on the previously developed ranking of the codecs. Following is a short discussion of the effect of tandem operation of each codec to give a rationale behind the subjective ranking which is based on limited data.

In the CLI codec, the spurious colored squares and stripes remain essentially unchanged. The jerky motion becomes more pronounced, and a little blurring is added. The color shift towards yellow becomes more noticeable but may have been caused by the frame synchronizer and not be inherent to the codec. Overall, the additional degradation caused by the double hop is not severe.

The main degradation in the GEC codec, namely the tear out in the bottom half of a picture with motion, is only slightly increased. The ragged edges during motion become more pronounced, and occasionally may wipe out some picture information. The most

DOUBLE HOP
CODEC 1: GEC
CODEC 3: CLI

SEQ	MEAN	STDEV	EVALUATORS 11	12	13
1	-2.3	0.58	-2	-2	-3
2	0.3	0.58	1	0	0
3	0.7	0.58	1	1	0
4	-1.3	0.58	-2	-1	-1
5	-1.0	1.00	-1	-2	0
6	-0.3	0.58	0	-1	0
7	-0.3	0.58	0	0	-1
8	-1.0	1.00	-2	-1	0
9	1.0	0.00	1	1	1
10	-1.0	0.00	-1	-1	-1
11	-1.0	0.00	-1	-1	-1
12	-2.0	0.00	-2	-2	-2
13	-0.7	1.15	-2	0	0
14	0.7	0.58	1	1	0
15	-1.0	1.00	-2	-1	0
16	-0.7	0.58	-1	-1	0
17	-0.3	1.15	-1	1	-1
18	0.0	0.00	0	0	0
19	-1.0	0.00	-1	-1	-1
20	-1.7	0.58	-2	-1	-2
21	-1.0	0.00	-1	-1	-1
22	-1.0	1.00	0	-1	-2
23	-1.7	0.58	-2	-1	-2
24	-1.7	0.58	-2	-1	-2
25	-1.0	0.00	-1	-1	-1
26	-0.3	1.53	-2	1	0
27	-1.7	0.58	-2	-1	-2
28	-1.0	1.00	0	-2	-1
29	-1.0	0.00	-1	-1	-1
30	-0.3	1.15	-1	1	-1
31	-2.3	0.58	-3	-2	-2
32	-0.3	0.58	0	-1	0
33	0.7	0.58	1	1	0
34	-0.3	1.53	-2	1	0
35	-1.0	1.00	-2	-1	0
36	-0.7	0.58	-1	0	-1
37	-1.7	0.58	-2	-1	-2
38	1.7	1.15	1	1	3
39	-0.3	1.15	1	-1	-1
40	0.0	0.00	0	0	0
41	-1.3	0.58	-2	-1	-1
42	-0.7	0.58	0	-1	-1
43	-1.7	0.58	-2	-2	-1
44	-1.0	1.00	-2	0	-1
45	-1.0	0.00	-1	-1	-1
46	-1.0	0.00	-1	-1	-1
MEAN			-0.93	-0.59	-0.74
STD.DEV.			1.12	0.96	1.00
GRADE			-0.75		

DOUBLE HOP
CODEC 1: GEC
CODEC 4: MEC

SEQ	MEAN	STDEV	EVALUATORS 11	12	13
1	1.3	0.58	1	1	2
2	1.3	0.58	2	1	1
3	0.7	0.58	1	1	0
4	1.3	0.58	2	1	1
5	2.0	0.00	2	2	2
6	1.0	0.00	1	1	1
7	1.7	0.58	2	2	1
8	0.7	1.15	2	0	0
9	1.0	1.00	2	1	0
10	1.0	0.00	1	1	1
11	1.3	0.58	2	1	1
12	1.0	1.73	2	2	-1
13	1.3	0.58	2	1	1
14	1.0	1.00	1	2	0
15	1.3	0.58	2	1	1
16	-0.3	1.15	-1	-1	1
17	1.3	0.58	1	2	1
18	0.3	0.58	1	0	0
19	1.0	0.00	1	1	1
20	1.7	1.15	3	1	1
21	2.0	0.00	2	2	2
22	1.7	0.58	2	1	2
23	0.0	1.00	1	-1	0
24	0.7	0.58	1	0	1
25	1.3	0.58	2	1	1
26	-0.3	1.15	-1	-1	1
27	1.0	1.00	1	0	2
28	1.0	1.73	0	0	3
29	1.7	0.58	1	2	2
30	1.7	0.58	1	2	2
31	1.7	0.58	1	2	2
32	1.3	0.58	1	1	2
33	0.7	0.58	1	1	0
34	0.7	0.58	1	1	0
35	1.0	1.00	2	1	0
36	1.3	0.58	1	1	2
37	1.0	1.00	0	1	2
38	1.7	0.58	2	1	2
39	0.7	0.58	1	1	0
40	0.0	1.00	-1	1	0
41	-0.7	0.58	-1	0	-1
42	2.0	1.00	2	1	3
43	1.3	1.15	0	2	2
44	1.0	0.00	1	1	1
45	1.7	0.58	1	2	2
46	1.3	0.58	1	1	2
MEAN			1.15	0.98	1.09
STD.DEV.			0.92	0.80	0.96
GRADE			1.07		

TABLE 4-8 DOUBLE HOP SCORES

noticeable effect of the double hop is in the coarsely grained after image which becomes much more pronounced and is retained over a longer period.

The NEC codec is severely affected by the moving spurious contour patterns which result in the processed picture containing much more motion than the input. When this picture is processed a second time, the codec cannot listinguish between real and spurious motion and a large amount of contour patterns is added. This problem is emphasized by tandem operation on a much more than linear scale and completely overshadows any other deterioration. Picture information is often obliterated and overall performance is largely unusuable.

SECTION 5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The testing of full motion codecs at 1.544 Mbps, which were available as finished products before the end of November 1984, has been successfully completed. The previously developed standard test tape was fed through the available codecs at locations selected by the manufacturers. The output was recorded only after agreement by the manufacturer's engineer that it represented the best performance of the codec. The output tapes were submitted to an impartial panel of evaluators for comparison scoring. Extreme care was taken to ensure that the evaluators would remain completely unbiased, and that the scores could in no way be affected by accidental differences in monitoring and test equipment or any other extraneous influences.

The results that were computed from the "raw" scores of the evaluators are fully consistent with each other. There are no contradictions or ambiguites that would have to be explained, the numbers speak for themselves and need no interpretation. A technical review by experts reached the same results. Thus the resulting ranking of the codecs is absolutely firm.

It must be emphasized that the purpose of the test is strictly the comparative evaluation of the various compression algorithms. Other factors, such as size, weight, ease of operation, special features, power consumption, reliability, maintenance requirements, cost and others become important in the selection of a specific equipment. However, the statement of this

task does not include consideration of any of these factors.

5.2 Recommendations

5.2.1 Objective Tests

The subjective test results of this task were all produced with the main part of the motion codec test tape. Recordings through all codecs were also made of the subsequent portion of the tape containing the standard signals for conventional analog tests and also signals that show promise for objective measurement of motion performance. It is recommended to compare the results of the subjective evaluations with the objective measurements and to determine the degree of correlation between them. This will require the use of a full capablity 1" tape recorder with still frame and single frame advance capabilty. This is not possible with portable recorders, therefore such tests will have to be performed in a recording studio where other test facilities are readily available. The expected result is a simplified methodology for motion codec testing which will reduce and maybe ultimately eliminate the need for subjective evaluation.

5.2.2 Updated Equipment Tests

Any test program in a rapidly developing technical area has the problem of achieving up-to-date results. It is impossible to wait for every improved equipment which is just about a finished product because the program could never be completed. Therefore November 1984 had to be established as the cutoff date, with the full realization that new equipments would be available within a

few months. It is recommended to update the presently developed codec performance scores when new equipments are available, provided such tests can be made compatible with the NCS standardization schedule.

INSTRUCTIONS FOR CODEC PICTURE EVALUATORS

The task of these tests is to judge the comparative quality of two TV pictures. There is no absolute way to measure this quality. Your judgement depends entirely on your personal impression and preference. The pictures you will have to judge are generally of poorer quality than the ones you are accustomed to see on your home receivers.

These tests pertain to the application of TV for teleconferencing which means the distant participants of the conference are seen on a monitor. This does not require the high picture quality of entertainment TV. Therefore, the picture is processed to allow lower cost transmission at some sacrifice in picture quality. Several processing equipments are available all of which produce different types and degrees of picture degradation. The purpose of this program is to determine which equipment produces the most acceptable picture for the teleconference user. You should put yourself in the position of the person looking at the pictorial information as if it were transmitted from the distant conference room.

On the two monitors in front of you, you will see the same picture but processed through two different equipments and therefore generally showing different degradations. The score sheets in your hands allow you to indicate if you consider the picture on either the left hand or right hand monitor slightly better, better, or much better than the other, or if you find both pictures of equal quality. You simply have to check the

applicable block. The difference between the three grades of "better" depends on your subjective judgement. It is not possible to list all potential types of degradations, but following are examples of what you are likely to encounter:

- Loss of resolution (sharpness)
- Bad or distorted colors
- Moving parts of picture fuzzy
- Moving parts of picture broken up
- Jerky motion
- Spurious lines and/or other patterns, mainly in the background
- Picture torn up and/or full of streaks
- Portions of more than one picture on screen at the same time

The pictures to be judged are recorded on video tape. Following the title, the main portion of the tape consists of 46 sequences, each averaging less than 30 seconds in length, followed by 10 seconds long numbered scoring intervals which give you time to consider and record your score. The sequences are an arbitrary mixture of still and many kinds of moving pictures, mostly in color. Some sequences consist of one continuous scene, others contain two or more different scenes. Your score should reflect your integrated impression of the whole sequence, not merely of one portion such as the end.

In the course of the tests you will see the same degraded sequences several times. There will even be repeats within the same test. Please score each sequence exclusively by your

impression at the instance you see it. Do not try to remember any previous score. Whenever different types of degradation produce pictures of very different appearance, it is up to your individual judgement to decide which one, if any, is better. Obviously, please do not look at anybody else's score, and do not discuss your results.

CODEC EVALUATION FORM

EVALUATOR: _____ TEST NO: _____

DATE: _____

GRADING SYSTEM

M; MUCH BETTER THAN	B; BETTER THAN	S; SLIGHTLY BETTER THAN	0; SAME AS

ENTER EVALUATION

TEST SEQ.	LEFT PICTURE BETTER			SAME AS	RIGHT PICTURE BETTER		
1	M	B	S	0	S	B	M
2	M	B	S	0	S	B	M
3	M	B	S	0	S	B	M
4	M	B	S	0	S	B	M
5	M	B	S	0	S	B	M
6	M	B	S	0	S	B	M
7	M	B	S	0	S	B	M
8	M	B	S	0	S	B	M
9	M	B	S	0	S	B	M
10	M	B	S	0	S	B	M
11	M	B	S	0	S	B	M
12	M	B	S	0	S	B	M
13	M	B	S	0	S	B	M

TEST SEQ.	LEFT PICTURE BETTER			SAME AS	RIGHT PICTURE BETTER		
14	M	B	S	0	S	B	M
15	M	B	S	0	S	B	M
16	M	B	S	0	S	B	M
17	M	B	S	0	S	B	M
18	M	B	S	0	S	B	M
19	M	B	S	0	S	B	M
20	M	B	S	0	S	B	M
21	M	B	S	0	S	B	M
22	M	B	S	0	S	B	M
23	M	B	S	0	S	B	M
24	M	B	S	0	S	B	M
25	M	B	S	0	S	B	M
26	M	B	S	0	S	B	M

CODEC EVALUATION FORM

(CONTINUATION)

EVALUATOR: _____ TEST NO: _____

DATE: _____

GRADING SYSTEM

M; MUCH BETTER THAN	B; BETTER THAN	S; SLIGHTLY BETTER THAN	0; SAME AS

ENTER EVALUATION

TEST SEQ.	LEFT PICTURE BETTER			SAME AS	RIGHT PICTURE BETTER		
27	M	B	S	0	S	B	M
28	M	B	S	0	S	B	M
29	M	B	S	0	S	B	M
30	M	B	S	0	S	B	M
31	M	B	S	0	S	B	M
32	M	B	S	0	S	B	M
33	M	B	S	0	S	B	M
34	M	B	S	0	S	B	M
35	M	B	S	0	S	B	M
36	M	B	S	0	S	B	M
37	M	B	S	0	S	B	M
38	M	B	S	0	S	B	M

TEST SEQ.	LEFT PICTURE BETTER			SAME AS	RIGHT PICTURE BETTER		
39	M	B	S	0	S	B	M
40	M	B	S	0	S	B	M
41	M	B	S	0	S	B	M
42	M	B	S	0	S	B	M
43	M	B	S	0	S	B	M
44	M	B	S	0	S	B	M
45	M	B	S	0	S	B	M
46	M	B	S	0	S	B	M
47	M	B	S	0	S	B	M
48	M	B	S	0	S	B	M
49	M	B	S	0	S	B	M

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This report covers the testing and ranking of motion codecs for teleconferencing operating at 1.544 Mbps. The tests utilized the motion codec test tape previously identified in NCS TIB 85-2 (Development of a Video Tape to Test Teleconferencing Codecs) and follows the methodology previously developed in NCS TIB 85-1 (Development of Methodology to test Video Codecs used in Teleconferencing). Codecs developed by four manufacturers were tested; this included all units which were available as regular products before the end of November 1984. Since the results of these tests are likely to have considerable impact on the manufacturers, extreme care was taken to ensure absolute impartiality and fairness in the procedure. Manufacturers' representatives actively participated in all testing and provided assurance that the results were representative of the performance capability of their equipment. .The subjective evaluation and ranking of the codecs employed all possible safeguards against external influences by test equipments or test arrangements and against any personal prejudice of the evaluators.

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